Exposure of humans to RF fields

As per FCC KDB 447498 D01 and Section 2.1091 radio frequency transmitters are required to be operated in a manner that ensures the public is not exposed to RF energy levels.

Calculations have been made using the General Public/Uncontrolled Exposure limits that are defined in Section 1.1310.

For worst case MPE calculations, 400 MHz has been selected.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3–3.0	614	1.63	*100	6
3.0–30	1842/f	4.89/f	*900/f^2	6
30–300	61.4	0.163	1.0	6
300–1,500			f/300	6
1,500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*100	30
1.34–30	824/f	2.19/f	*180/f^2	30
30–300	27.5	0.073	0.2	30
300–1,500			f/1500	30
1,500–100,000			1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

Limits for maximum permissible exposure (MPE)

- General Population / Uncontrolled exposure is f/1500. At 400.0 MHz, the calculated limit is 0.27 mW/cm^2

- Occupational /Controlled exposure is f/300. At 400.0 MHz, the calculated limit is 1.33 mW/cm^2

Minimum safe distances have been calculated below.

For Uncontrolled Environment

At 400 MHz, Power Density = 0.27 mW/cm^2 = $E^2/3770$

E= √ 0.27*3770

E = 31.9 V/m

For Controlled Environment

At 400.0 MHz, Power Density = 1.33 mW/cm^2 = E^2/3770

E= √ 1.33*3770

E = 70.8 V/m

The rated maximum transmitter power (CW) = 0.25 W (+24 dBm).

A worst case scenario duty cycle of 100% has been used for the calculations.

The following information about the antenna type and gain has been obtained from the client:

Antenna Type	Gain (dBi)
Omni	10 dBi
Panel	10 dBi
Panel	15 dBi

The minimum distance from the antenna at which the MPE is met is calculated from the following

Field strength in V/m (FS),
Transmit power in watts (P)
Transmit antenna gain (G)
Transmitter duty cycle (DC)
Separation distance in metres (D)

The calculation is as follows:

FS = (√ (30 * P * G * DC)) / D

The calculations have been shown with following scenarios:

- MPE calculations for the product with both ports terminated in a 50 Ohm load
- Using 10 dBi gain antenna
- Using 15 dBi gain antenna

a) For Uncontrolled environments, the minimum distance is:

D = (√ (30 * P * G * DC)) / FS

P = 0.25 W

FS = 31.9 V/m

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
400.000	No gain (0)	1.0	100%	0.09
400.000	10.0	10.0	100%	0.27
400.000	15.0	31.6	100%	0.48

a) For Controlled environments, the minimum distance is:

D = (√ (30 * P * G * DC)) / FS

P = 0.25 W

FS = 70.8 V/m

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
400.000	No gain (0)	1.0	100%	0.04
400.000	10.0	10.0	100%	0.12
400.000	15.0	31.6	100%	0.22

Result: Complies if the safe distances shown in the calculations above are followed.